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FOR

METHOD FOR PRODUCING SOFT BULKY TISSUE

OF

PAUL BEUTHER

FRANK DRUECKE

AND

JEFF HOLZ

METHOD FOR PRODUCING SOFT BULKY TISSUE

Background of the Invention

Many tissue products, such as facial tissue, bath tissue, paper towels, industrial wipers, and the like, are produced according to a wet laid process. Wet laid webs are made by depositing an aqueous suspension of pulp fibers onto a forming fabric and then removing water from the newly-formed web. Water is typically removed from the web by mechanically pressing water out of the web which is referred to as "wet-pressing". Although wet-pressing is an effective dewatering process, during the process the tissue web is compressed causing a marked reduction in the caliper of the web and in the bulk of the web.

For most applications, however, it is desirable to provide the final product with as much bulk as possible without compromising other product attributes. Thus, those skilled in the art have devised various processes and techniques in order to increase the bulk of wet laid webs. For example, creping is often used to disrupt paper bonds and increase the bulk of tissue webs. During a creping process, a tissue web is adhered to a heated cylinder and then creped from the cylinder using a creping blade.

Another process used to increase web bulk is known as "rush transfer". During a rush transfer process, a web is transferred from a first moving fabric to a second moving fabric in which the second fabric is moving at a slower speed than the first fabric. Rush transfer processes increase the bulk, caliper and softness of the tissue web.

As an alternative to wet-pressing processes, through-drying processes have developed in which web compression is avoided as much as possible in order to preserve and enhance the bulk of the web. These processes provide for supporting the web on a coarse mesh fabric while heated air is passed through the web to remove moisture and dry the web.

Although through-dried tissue products exhibit good bulk and softness properties, through-drying tissue machines are expensive to build and operate. Accordingly, a need exists for producing higher quality tissue products by modifying existing, conventional, wet-pressing tissue machines.

In this regard, U.S. Patent No. 5,411,636 to Hermans, et al., which is incorporated herein by reference, discloses a process for improving the internal

bulk of a tissue web by subjecting the tissue web to differential pressure while supported on a coarse fabric at a consistency of about 30% or greater. The processes disclosed in the '636 patent provide various advantages in the art of tissue making, without having to completely dry a web using a through-air dryer.

Additional improvements in the art, however, are still needed. In particular, a need currently exists for an improved process that reorients fibers in a tissue web for increasing the bulk and softness of the web without having to subject the web to a rush transfer process or to a creping process. A need also exists for a process that increases the bulk and softness of a web without significantly adversely affecting other properties of the web.

Summary of the Invention

The present invention is generally directed to further improvements in the art of tissue making. Through the processes and methods of the present invention, the properties of a tissue web, such as the bulk of the web, may be improved. The methods and processes of the present invention may incorporate various conventional techniques or may be used to replace conventional techniques. For example, the process of the present invention may be used as a replacement to a rush transfer process or a through-drying process, or may be used in conjunction with rush transfer or a through-air dryer.

In one embodiment, the process for producing a tissue web in accordance with the present invention may include the steps of first depositing an aqueous suspension of papermaking fibers onto a forming fabric to form a wet web. The wet web is dewatered to a consistency of about 30% to about 65%, such as from about 40% to about 60%.

According to the present invention, the tissue web is deflected multiple times in between opposing transfer fabrics such that the web is biased against the opposing fabrics at least three different times. During the multiple deflections, the fibers within the web become rearranged, increasing the bulk of the web. For example, in one embodiment, the tissue web is molded against the fabrics, meaning that fiber rearrangement occurs such that the web assumes the typography of the fabrics. Molding the tissue web onto one fabric and then molding the web in the reverse direction onto a different fabric in a partially dry

state provides significant fiber disruption sufficient to improve the properties of the web.

After being deflected multiple times, the tissue web is then dried to a final dryness.

The multiple deflections of the present invention may occur, in one embodiment, in between a first fabric and a second fabric. In this embodiment, for instance, a first side of the web may be biased against the first fabric and then the second side of the web may be biased against the second fabric. After the second side of the web is biased against the second fabric, the first side of the web may be once again biased against the first fabric. In other embodiments, however, three fabrics may be used in order to carry out the multiple deflections. Further, it should be understood that greater than three deflections may occur during the process.

In one embodiment, the dewatered tissue web is deflected multiple times using pneumatic pressure. For instance, web transfers can be carried out using gas emitting devices that emit a gas at a pressure sufficient to push the web from one transfer fabric to an opposing transfer fabric. Alternatively, or in addition to using a gas emitting device, a suction device may be used that pulls a web from one transfer fabric to an opposing deposing fabric. Gas pressures of such devices can be at least, for instance, 5 inches of Hg, such as from about 10 inches Hg to about 60 inches Hg and particularly, from about 10 inches Hg to about 20 inches Hg.

Tissue webs made according to the present invention can have a bulk of at least 10cc/g, such as at least 15 cc/g prior to being wound into a roll. Although the process of the present invention can be used to form any tissue web, the process, in one embodiment, is configured to produce facial tissues and bath tissues having a basis weight of from about 6 gsm to about 45 gsm. In other embodiments, the process may be used to form wiping products, such as paper towels, having a basis weight of greater than about 30 gsm, such as from about 30 gsm to about 120 gsm.

In order to dry the web to a final dryness, in one embodiment, the web may be adhered to a heated drying cylinder and then creped from the cylinder. For

example, in one embodiment, an adhesive may be used to adhere the web to the drying cylinder.

In order to dewater the web, the tissue web may be fed, in one embodiment, through a nip defined by a pair of opposing press rolls. In an alternative embodiment, however, a through-air dryer may be used in order to dewater the web to a desired consistency.

In one particular embodiment of the present invention, the multiple deflections are carried out on a deflection roll. The deflection roll may include at least one gas emitting zone and at least one gas receiving zone. The tissue web is conveyed around the deflection roll while sandwiched between two transfer fabrics. The wrap of the fabrics around the deflection roll is such that the web passes over the gas emitting zone and the gas receiving zone. For instance, in one embodiment, the fabrics are wrapped around the deflection roll at least 30 degrees.

When passing over the gas emitting zone, a gas is emitted from the deflection roll that deflects the web from one transfer fabric to an opposing fabric. Similarly, when the web is passed over the gas receiving zone, the web is transferred from one of the transfer fabrics to an opposing transfer fabric.

In order to provide gas flow into and out of the deflection roll, the deflection roll can be placed in communication with a vacuum source and/or a pressurized gas source. In one particular embodiment, a hood is placed over the deflection roll. A pressurized gas source emits a gas through the gas emitting zone. The hood is in communication with the gas emitting zone and is configured to redirect the gas flow from the gas emitting zone and into the gas receiving zone of the roll. Similarly, the hood may also be configured to direct a gas flow created by a vacuum source.

In one embodiment, the deflection roll includes at least two gas emitting zones. The gas receiving zone is positioned in between the two gas emitting zones. In an alternative embodiment, the deflection roll includes at least two gas receiving zones, wherein the gas emitting zone is positioned in between the two gas receiving zones.

Other features and aspects of the present invention are discussed in greater detail below.

Brief Description of the Drawings

The following is a detailed description of the present invention including reference to the following figures in which:

Figure 1 is a side view of one embodiment of a process made in accordance with the present invention;

Figure 2 is a side view of one embodiment of a deflection roll made in accordance with the present invention;

Figure 3 is a side view of another embodiment of a process made in accordance with the present invention;

Figure 4 is a side view of still another embodiment of a process made in accordance with the present invention;

Figure 5 is a partial side view showing another method for deflecting a tissue web multiple times in between a pair of transfer fabrics; and

Figure 6 is a side view of another embodiment of a process made in accordance with the present invention.

Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the invention.

Detailed Description of Preferred Embodiments

It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention, which broader aspects are embodied in the exemplary constructions.

In general, the present invention is directed to the formation of tissue webs having good bulk and softness properties while maintaining adequate strength properties. In general, the tissue webs are made by deflecting a partially dried web made from papermaking fibers multiple times. For instance, in one embodiment, the partially dried tissue web is deflected at least three times in between a first fabric and a second fabric. For example, in one embodiment, the web can be biased against opposing fabrics at least four times, such as at least five times.

As used herein, the term “deflection” refers to a process in which a tissue web is biased against an opposing surface with a force sufficient to cause at least

some of the fibers in the web to reorient. In some embodiments, the force may be sufficient to cause the web to mold and conform to the topography of the surface.

In one embodiment, the multiple fabric deflections may be carried out using pneumatic pressure. For example, suction or vacuum devices and/or pressure devices may be used for deflecting the tissue web from one fabric to another. In one particular embodiment of the present invention, a deflection roll may be used that includes a fabric sleeve and alternating gas emitting zones and gas receiving zones.

Referring to Figure 1, one embodiment of a tissue making process in accordance with the present invention is shown. As illustrated, the system includes a head box **10** which deposits an aqueous suspension of papermaking fibers onto a forming fabric **12**. The papermaking fibers can include, but are not limited to, all known cellulosic fibers or fiber mixes comprising cellulosic fibers. The fibers can include, for example, hardwood fibers such as eucalyptus fibers or softwood fibers, such as northern softwood kraft fibers. Other fibers may include high-yield fibers, recycled fibers, broke, synthetic cellulosic fibers, and the like.

Once the aqueous suspension of fibers is deposited onto the forming fabric **12**, some of the water contained in the aqueous suspension is drained through the fabric and a tissue web **14** is formed. The wet web **14** retained on the surface of the forming fabric has a consistency of about 10%.

As shown in Figure 1, the wet tissue web **14** is transferred to a first transfer fabric **16** which may be, for instance, a papermaking felt. In accordance with the present invention, the tissue web **14** is then fed into a press nip **18** and further dewatered. The press nip **18** is formed between the first transfer fabric **16** and a second transfer fabric **20** utilizing a first press roll **22** and a second press roll **24**. The press nip further dewaters the tissue web **14** to a consistency of about 30% or greater, such as from about 30% to about 65%. In one particular embodiment, for example, the tissue web is dewatered in the nip **18** to a consistency of about 40% to about 60%.

In Figure 1, a press nip is shown formed between a pair of opposing press rolls. In other embodiments, multiple press nips may be used in order to dewater the web. Further, instead of or in addition to press nips, shoe-type presses may

also be used to dewater the web. In further embodiments, a through-air dryer may be used in order to dewater the web.

From the nip **18**, the tissue web **14** is conveyed on the second transfer fabric **20** and then transferred to a third transfer fabric **26**. If needed, a vacuum roll **28** or other suitable transfer device may be used in order to guide the web onto the third transfer fabric **26**.

While carried on the third transfer fabric **26**, the tissue web **14** is passed over a deflection roll **28**. One embodiment of a deflection roll is more particularly shown in Figure 2. As illustrated, the deflection roll **28** includes a fabric sleeve **30** that surrounds the roll. The tissue web **14** is passed around the deflection roll **28** in between the third transfer fabric **26** and the fabric sleeve **30**. For many applications, the tissue web **14** and the third transfer fabric **26** have a wrap around the deflection roll **28** of at least about 30 degrees.

The deflection roll **28** is porous and air permeable to allow the flow of air through the roll. For example, in one embodiment, the deflection roll can be made from metal in a honeycomb-like configuration. In this embodiment, the deflection roll has a particular thickness to allow for support of the channels running through the honeycomb pattern. In other embodiments, however, other various porous arrangements may be used in constructing the deflection roll.

As shown in Figure 2, the deflection roll **28** includes a center area **32** that is in fluid communication with a plurality of gas emitting zones **34**, **36** and **38**. The deflection roll **28** further includes a hood **40** that surrounds the gas emitting zones. Not shown, the hood **40** may include seals that adequately seal the hood to the deflection roll against the outside atmosphere. The hood **40** is in fluid communication with a plurality of gas receiving zones **42** and **44**. The deflection roll **28** further includes a gas exhaust **46**.

In the embodiment shown in Figure 2, a pressurized gas source (not shown), such as a fan or a blower, flows a pressurized gas such as air or a heated gas into each of the gas emitting zones **34**, **36** and **38**. The gas flows to the gas emitting zones, through the fabric sleeve **30**, through the third transfer fabric **26**, and into the hood **40**. The hood **40** is then configured to redirect the gas back into the gas receiving zones **42** and **44**. Gas is then exhausted through the gas exhaust **46**.

In this manner, the tissue web **14** passes over multiple and alternating gas emitting zones and gas receiving zones. When passing over the gas emitting zone **34**, the tissue web **14** is deflected against the third transfer fabric **26**. When passing over the gas receiving zone **42**, on the other hand, the tissue web **14** is deflected against the fabric sleeve. Next, the tissue web **14** passes over the gas emitting zone **38** and is deflected against the transfer fabric **26**, then deflected against the fabric sleeve **30** after passing over the gas receiving zone **44**. Finally, when passing over the gas emitting zone **36**, the tissue web **14** is once again deflected against the transfer fabric **26**.

In this manner, the tissue web **14** is deflected five times. It should be understood, however, that the deflection roll **28** may include more or less gas emitting zones and more or less gas receiving zones. For instance, in one embodiment, the deflection roll **28** includes a single gas emitting zone and a single gas receiving zone.

In the embodiment illustrated in Figure 2, the pressurized gas source is used in order to convey a fluid such as air through the deflection roll **28**. In other embodiments, however, various other gas flow configurations are possible. For example, in an alternative embodiment, the center area **32** may be placed in communication with a suction device or a vacuum source for creating air flow within the gas receiving zones **42** and **44**. The gas flow through the gas receiving zones may then be redirected into the gas emitting zones.

In still another embodiment, the deflection device **28** can be placed in communication with one or more pressurized gas sources for feeding a pressurized gas into the gas emitting zones and may be placed in communication with one or more suction devices for creating a suction force within each of the gas receiving zones.

The amount of pneumatic pressure that is generated within each of the zones may vary depending upon the particular application. Further, the pressure from zone to zone may vary as well. In general, gas pressures within the zones can be at least 1 inch Hg, at least 2 inches Hg, such as at least 4 inches Hg. The pressures may vary, for instance, from about 1 inch Hg to about 60 inches Hg, such as from about 4 inches Hg to about 20 inches Hg.

The particular amount of pressure needed in each of the zones may be dependent upon the amount of deflection of the web that is desired. For example, in one embodiment, pressures may be used that are sufficient to cause the tissue web to mold against the transfer fabric and/or the fabric sleeve. When molding occurs, fibers within the tissue web are rearranged causing the web to form a reverse impression of the fabric that the web is deflected against. The present inventors believe that the rearrangement of fibers caused by deflection against both sides of the web in a partially dry state provides significant disruption of the fiber bonds to create improved bulk and softness characteristics.

The fabrics that are used in the processes of the present invention for deflecting the tissue web may vary depending upon the particular circumstances. In one embodiment, for instance, coarse fabrics may be used for either assisting in fiber bond disruption during deflection or for simply creating a more aesthetically appealing product.

Referring back to Figure 1, from the deflection roll **28**, the tissue web **14** is carried on the third transfer fabric **26** to a drying cylinder **48**. The drying cylinder **48** may be, for instance, a Yankee dryer.

In one embodiment, an adhesive may be applied to the tissue web or to the dryer for adhering the web to the dryer. The adhesive may be, for instance, any suitable or conventionally used adhesive. For instance, in one embodiment, an adhesive containing polyvinyl alcohol may be used. The adhesive may be, for instance, sprayed onto the web. As shown in Figure 1, once adhered to the drying cylinder **48**, the tissue web **14** is creped from the cylinder using a creping blade **50**. Creping the web serves to further cause fiber disruption and increase the bulk of the web. Once creped, the tissue web is wound onto a reel for converting and later packaging.

Although the process in Figure 1 shows the use of a drying cylinder and creping blade, it should be understood that any suitable drying device may be used in the present invention. For example, in other embodiments, the process may include a through-air dryer.

The process of the present invention is particularly well suited to producing all different types of tissue products. The tissue products can have, for instance, a basis weight of from about 6 gsm to about 120 gsm. Tissue products that may be

produced according to the present invention include paper towels, industrial wipers, and various products.

In one particular embodiment of the present invention, the process is used to produce facial tissue or bath tissue. The facial tissue webs or bath tissue webs can have a basis weight, for instance, of from about 6 gsm to about 45 gsm, such as from about 10 gsm to about 15 gsm. The final product can contain a single ply or can contain multiple plies (2 to 3 plies).

As described above, tissue products made according to the present invention have improved softness and bulk properties, while maintaining adequate strength and stiffness properties. In fact, tissue webs made according to the present invention can have a bulk prior to being wound into a parent roll of at least about 15 cc/g, such as from about 15 cc/g to about 20 cc/g. Further, the above bulk properties may be obtained without ever through-drying the web. The above bulk properties can also be achieved without having to subject the tissue web to a rush transfer process. In fact, the process of the present invention utilizing multiple deflections may be used to replace a rush transfer operation altogether.

During converting, the tissue web is typically calendered and packaged. After calendering, the tissue web may have a bulk of greater than about 7.5 cc/g, such as greater than about 8 cc/g. For example, in one embodiment, after being calendered, the tissue web may have a bulk of from about 8 cc/g to about 13 cc/g, such as from about 9 cc/g to about 11 cc/g.

In Figure 1, multiple deflections of the partially dried tissue web occur along the surface of the deflection roll **28**. In other embodiments, other devices may be used in order to carry out the multiple deflections. For example, referring to Figure 5, the tissue web **14** is shown in between a first transfer fabric **52** and a second transfer fabric **54**. In this embodiment, the tissue web **14** is carried on the first transfer fabric **52** and then deflected against the second transfer **54** using a suction device **56**. The suction device can be, for instance, a vacuum box, a vacuum shoe, or a vacuum roll.

As shown, once the web **14** passes over the suction device **56**, the web is deflected back against the first transfer fabric **52** using a second suction device **58**. Next, the tissue web is deflected against the second transfer fabric **54** by a third suction device **60**. In this manner, the web is deflected three times. In other

embodiments, however, further suction devices may be included for carrying out further deflections.

The arrangement shown in Figure 5 may be used to replace the deflection roll **28** as shown in Figure 1. An additional transfer fabric and the suction devices, for instance, may be placed where the deflection roll is located.

In the embodiments shown in Figure 5, suction devices **56**, **58** and **60** accomplish the multiple deflections. In other embodiments, however, it should be understood that in addition or instead of suction devices, various pressurized devices may be used that instead of pulling a tissue web onto a fabric, push a web against a fabric. The pressurized devices may include, for instance, a pressurized shoe or a pressurized roll that emits a fluid, such as air, against the tissue web. The pressurized device may be used to replace the suction devices shown in Figure 5 or may be used in conjunction with the suction devices. For instance, a pressurized device may be placed downstream of such a device or may be placed opposite a suction device for either carrying out a deflection on its own or carrying out a deflection in conjunction with the suction device.

In the embodiments shown in Figure 5, only two opposing transfer fabrics **52** and **54** are shown. It should be understood, however, that further fabrics may be used if desired. For instance, each deflection may be carried out against a different fabric. The fabrics may have the same or different topographies.

In Figure 5, the tissue web **14** is also shown in continuous contact with fabrics **52** and **54** during the multiple deflections. It should also be understood, however, that in other embodiments, the tissue web **14** may actually transfer from one transfer fabric to the other transfer fabric during the deflections. In fact, fabric transfers can also occur when using the deflection roll as shown in Figure 1. Actual web transfers are not needed, however, in order to reorient the fibers of the web in accordance with the present invention.

Referring to Figures 3, 4 and 6, other processes in accordance with the present invention are illustrated. For example, referring to Figure 3, a process similar to the process illustrated in Figure 1 is shown. As illustrated, a head box **110** emits an aqueous slurry of papermaking fibers onto a forming fabric **112** for forming a wet tissue web **114**. From the forming fabric **112**, the tissue web is transferred to a first transfer fabric **116** and fed into a press nip **118** for partially

dewatering the web to a consistency of from about 30% to about 70%. In this embodiment, instead of being transferred to a second transfer fabric **120**, the tissue web **114** remains on the first transfer fabric **116** when exiting the nip **118**. From the first transfer fabric **116**, the web is then transferred to a third transfer fabric **126** and fed through a deflection roll **128**.

In accordance with the present invention, while passing over the deflection roll, the tissue web is deflected multiple times between the third transfer fabric **126** and a fabric sleeve **130**. The deflection roll **128** includes at least one gas emitting zone and at least one gas receiving zone for deflecting a web.

From the deflection roll **128**, the tissue web **114** is adhered to a drying cylinder **148** and creped from the cylinder using a creping blade **150**.

In the embodiment illustrated in Figure 3, a transfer roll **152** is present for assisting in the transfer of the web from the first transfer fabric **116** to the third transfer fabric **126**.

Referring to Figure 4, a similar process to the one shown in Figure 3 is illustrated. Like reference numerals have been included to represent similar elements or features. As shown, in the embodiment illustrated in Figure 4, the transfer roll **152** has been eliminated and the tissue web **114** is transferred directly to the deflection roll **128** from the first transfer fabric **116**. In the process shown in Figure 4, the tissue web **114** is dewatered to a consistency of from about 30% to about 65% and then deflected multiple times in between a third transfer fabric **126** and a fabric sleeve **130** wrapped around the deflection roll **128**. Once deflected multiple times, the tissue web **114** is then dried to a final dryness using a drying cylinder **148**. The web is also adhered to the drying cylinder and creped from the cylinder using a creping blade **150**.

One of the advantages to the present invention is that conventional papermaking lines may be easily modified into a process in accordance with the present invention. For instance, as shown in the processes illustrated in Figures 1, 3 and 4, a press nip is used to dewater the tissue web and a deflection roll is used to deflect the partially dried web multiple times. These elements may be easily incorporated into most existing processing lines. By conforming a conventional process line to the teachings of the present invention, tissue webs may be produced having improved properties.

In fact, tissue webs made according to the present invention may have properties very comparable to through-air dried webs without having to incorporate a through-air dryer into the system. For instance, through-air dryers are relatively expensive to manufacture and operate. Further, paper processing lines typically need to be entirely reworked when attempting to incorporate a through-dryer into the system.

It should be understood, however, that a through-air dryer may be used in a process of the present invention. For instance, in one embodiment, as described above, a through-air dryer may be used to partially dry a web prior to the web being deflected multiple times. For example, referring to Figure 6, a process is shown in which a head box **210** deposits an aqueous suspension of papermaking fibers onto a forming fabric **212** to form a wet tissue web **214**. The wet tissue web is transferred from the forming fabric **212** to a through-drying fabric **216**.

Once transferred to the through-drying fabric **216**, the tissue web **214** is fed into a through-air dryer **270**. The through-air dryer **270** includes a drying cylinder **272** and a hood **274**. In order to partially dry the tissue web **214**, heated air flows either from the hood **274** into the drying cylinder **272** or flows from the drying cylinder **272** into the hood **274**.

Once the tissue web **214** is dried to a consistency of about 30% to about 70%, the tissue web is then fed to a deflection roll **228** located along the through-drying fabric **216**. The tissue web is fed in between the through-drying fabric **216** and a fabric sleeve **230**. As the web travels along the deflection roll, the web is deflected multiple times. Next, the tissue web **214** is adhered to a drying cylinder **248** and creped using a creping blade **250**.

The present invention may be better understood with reference to the following example.

<u>Example</u>

The following example was performed in order to demonstrate the effect multiple deflections have on a semi-dry tissue web.

During this example, the following tests were performed on various samples:

<u>Geometric mean tensile strength</u> (GMT) is the square root of the product of the machine direction tensile strength and the cross-machine direction tensile

strength of the web (in Nm/g). As used herein, tensile strength refers to mean tensile strength as would be apparent to one skilled on the art (in Nm/g). Geometric tensile strengths are measured using a MTS Synergy tensile tester using a 1 inch sample width, a jaw span of 2 inches was used for machine direction tests and 3 inches for cross machine direction tests, and a crosshead speed of 10 inches per minute after maintaining the sample under TAPPI conditions for 4 hours before testing. A 50 Newton maximum load cell is utilized in the tensile test instrument.

Machine Direction Slope or Cross-Machine Direction Slope is a measure of the stiffness of a sheet and is also referred to as elastic modulus (in kilogram-force). The slope of a sample in the machine direction or the cross-machine direction is a measure of the slope of a stress-strain curve of a sheet taken during a test of tensile testing (see geometric mean tensile strength definition above) and is expressed in units of kilograms of force. In particular, the slope is taken as the least squares fit of the data between stress values of 70 grams of force and 157 grams of force.

Machine Direction Stretch and Cross Machine Direction Stretch is the amount of stretch the sample undergoes prior to failure when placed in a tensile tester as described above with respect to slope and geometric mean tensile strength. Stretch is measured in percent.

Caliper was measured in microns using the Emveco Caliper Tester, which measures caliper under a load of 2 kPa.

Handsheets were formed from a fiber furnish containing 65% by weight eucalyptus fibers and 35% by weight northern softwood kraft fibers. Each of the handsheets had a basis weight of about 20 gsm.

Each of the handsheets were dewatered to approximately 60% consistency using a Carver press. Blotter papers were placed on the top and bottom of the press during the dewatering process.

Five of the handsheets were then deflected once on a fabric. The fabric used was manufactured by Voith Fabrics under the trade name 44MST and was a 42 x 36 fabric with 0.35 mm diameter machine direction strands and 0.41 mm cross machine direction strands. To carry out the deflection, the handsheet was placed on the fabric. A nozzle from a shop vac was placed below the fabric. The

sheet, while on the fabric, was then passed over the nozzle while the shop vac was operating. It is believed that the shop vac created pressure in an amount of approximately 30 inches of water.

Five other samples of the handsheets were then deflected three times using a similar procedure. In particular, the handsheets were deflected twice on one side of the sheet and once on an opposite side of the sheet. The two deflections carried out on the same side of the sheet were done using the fabric described above. The opposite side of the sheet was deflected on a 44GST fabric manufactured by Voith Fabrics and was a 42 x 34 fabric, with 0.35 mm diameter machine direction strands and 0.41 mm cross direction strands.

The following results were obtained:

Control – One Deflection									
Sample No.	**Consistency**	**Caliper (microns)**	**MD Tensile**	**CD Tensile**	**GMT**	**MD-stretch**	**CD-stretch**	**MD-slope**	**CD-slope**
Control 1	67	109	8.34	5.86	6.99	1.31	1.67	48.46	23.01
Control 2	61	157	6.89	7.25	7.07	1.46	1.62	33.25	34.22
Control 3	60	116	7.80	7.09	7.44	1.51	1.30	28.72	36.68
Control 4	62	110	8.96	6.70	7.75	1.32	1.27	44.16	35.14
Control 5	62	114	8.88	8.04	8.45	1.30	1.87	46.23	28.46
Average	62.4	121	8.2	7.0	7.5				

Handsheets Deflected Three Times									
Sample No.	**Consistency**	**Caliper (microns)**	**MD Tensile**	**CD Tensile**	**GMT**	**MD-stretch**	**CD-stretch**	**MD-slope**	**CD-slope**
1	61	113	6.60	6.38	6.49	1.32	0.99	36.19	44.18
2	64	120	8.13	5.72	6.82	1.08	1.21	49.51	29.50
3	63	187	8.36	6.09	7.14	1.44	1.15	46.54	38.24
4	61	173	6.75	7.55	7.14	1.56	1.15	29.88	47.01

5	66	127	7.16	7.72	7.43	1.91	1.21	23.93	44.30
Average	63	144	7.4	6.7	7.0.				

As shown above, the handsheets that were deflected multiple times showed an increase in caliper and a decrease in geometric mean tensile strength, indicating a decrease in stiffness.

These and other modifications and variations to the present invention may be practiced by those of ordinary skill in the art, without departing from the spirit and scope of the present invention, which is more particularly set forth in the appended claims. In addition, it should be understood that aspects of the various embodiments may be interchanged both in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the invention so further described in such appended claims.